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PRELIMINARY EVALUATION OF THE HYDROGEOLOGIC AND WATER-QUALITY DATA FROM THE PHASE IV WELLS LOCATED IN THE BEAR CREEK VALLEY WASTE DISPOSAL AREA FOR THE PERIOD SUMMER 1985 - SEPTEMBER 1986

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November 1987

Document Prepared by
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Oak Ridge, Tennessee 37830

for

Oak Ridge Y-12 Plant
Oak Ridge, Tennessee 37831
operated by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
Under Contract No. DE-AC05-84OR21400

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PRELIMINARY EVALUATION OF THE HYDROGEOLOGIC AND WATER-QUALITY DATA FROM THE PHASE IV WELLS LOCATED IN THE BEAR CREEK VALLEY WASTE DISPOSAL AREA FOR THE PERIOD SUMMER 1985 - SEPTEMBER 1986

This document was written by
Geraghty & Miller, Inc., under
subcontract to Martin Marietta
Energy Systems, Inc.

Oak Ridge Y-12 Plant
Oak Ridge, Tennessee 37831
operated by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
Under Contract No. DE-AC05-84OR21400

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FINAL REPORT

PRELIMINARY EVALUATION OF THE HYDROGEOLOGIC AND WATER-QUALITY DATA FROM PHASE IV WELLS LOCATED IN THE BEAR CREEK VALLEY WASTE DISPOSAL AREA FOR THE PERIOD SUMMER 1985 - SEPTEMBER 1986

Prepared by

Geraghty & Miller, Inc
Under Purchase Order 12Y-00206C

for

Oak Ridge Y-12 Plant
Oak Ridge, Tennessee 37831

Operated by

MARTIN MARIETTA ENERGY SYSTEMS, INC.
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Under Contract No. DE-AC05-84OR21400

GERAGHTY & MILLER, INC.
Ground-Water Consultants
255 South Tulane Avenue
Oak Ridge, Tennessee 37830

GERAGHTY
& MILLER, INC.
Ground-Water Consultants
Our 30th year

November 2, 1987

Mr. Lowell L. McCauley
Martin Marietta Energy Systems, Inc.
Y-12 Area, Bldg. 9704-1
P. O. Box Y
Oak Ridge TN 37830

RE: "Preliminary Evaluation of the Hydrogeologic and Water-Quality Data from Phase IV Wells Located in the Bear Creek Valley Waste Disposal Area for the Period Summer 1985-September 1986," Final Report

Dear Lowell:

Submitted here in final form are four bound reports and one master copy for reproduction of the above-referenced study of the hydraulic conductivity and the water quality data from the Phase IV wells. The hydraulic conductivity values reported in the original document have been revised as a result of an attempt at a more consistent approach through calculating the values over approximately the entire recovery time for each well. These changes were generally proportional and thus have not affected the conclusions stated in the original draft. As requested, the calculations have been included as an Appendix.

As stated in the report the chemical data from the October 1985 sampling episode were not collected in accordance with appropriate protocols and therefore must be regarded as somewhat suspect. A more complete set of chemical data will be available at the end of this year which should reveal a more clear picture of the water chemistry in the deep wells. Interpretations of these data will be included in the annual assessment report for 1987 to be submitted to the State by March 1, 1988.

Please do not hesitate to contact us if you have any questions or comments. We appreciate the opportunity to be of service.

Very truly yours,
Geraghty & Miller, Inc.

Jerry A. Archer
Senior Scientist

cc: C. D. Henry
OR-87-308

255 South Tulane Avenue • Oak Ridge, Tennessee 37830-6725 • (615) 481-3000

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1.0 INTRODUCTION

1.1 BACKGROUND

On May 26, 1983, representatives of the U.S. Department of Energy (DOE) signed a Memorandum of Understanding (MOU) with the U.S. Environmental Protection Agency and the Tennessee Department of Health and Environment (TDHE) relating to control of contamination in the Bear Creek Valley Waste Disposal Area (BCVWDA) adjacent to DOE's Y-12 Plant in Oak Ridge, Tennessee. The intent of the MOU, as modified by a TDHE Complaint and Order dated December 1983, was to establish an approach for evaluating remedial-action alternatives in the BCVWDA.

In June 1985, Energy Systems issued a report, prepared by Geraghty & Miller, Inc., (G&M) entitled "Remedial Alternatives for the Bear Creek Valley Waste Disposal Area," which described four alternative remedial-action plans developed in response to the requirements of the regulating agencies. The report included a recommendation for installation of additional montior wells, which were installed in 1985 as the Phase IV Drilling Program.

1.2 THE BCVWDA

The BCVWDA consists of three principal waste-disposal sites: the S-3 Ponds; the Oil Landfarm, which includes the Sanitary Landfill; and the Burial Grounds, situated over a distance of roughly two miles in the valley of Bear Creek

(Figure 1-1). The BCVWDA has been used since 1951 for disposal of a wide variety of wastes. The valley, which extends in a general east-west direction, is bordered on the north by Pine Ridge and on the south by Chestnut Ridge. Bear Creek flows westward through the valley to drain into East Fork Poplar Creek, which empties into Poplar Creek, a tributary of the Clinch River.

The bedrock formations underlying the BCVWDA consist largely of stratified shales and limestones, overlain by unconsolidated soil materials derived from weathering of those rocks. The hydrogeologic system, for all practical purposes, can be thought of as a single aquifer of relatively low water-transmitting capacity. The upper, unconsolidated part of this aquifer is somewhat more permeable than the deeper parts, but there is no sharp discontinuity in permeability between them, and both respond in the same general way with respect to water-level fluctuations and the movement of ground water toward Bear Creek.

The aquifer is anisotropic, particularly in unweathered bedrock zones, where sharp differences in permeability exist across the numerous thin dipping layers or beds. As a result of the anisotropy, permeability values normal to the bedding may be as much as ten times lower than those parallel to the bedding. Moreover, several sets of intersecting joints and fractures provide preferred flow paths and contribute to the complexity of the flow system. Local deviations from the

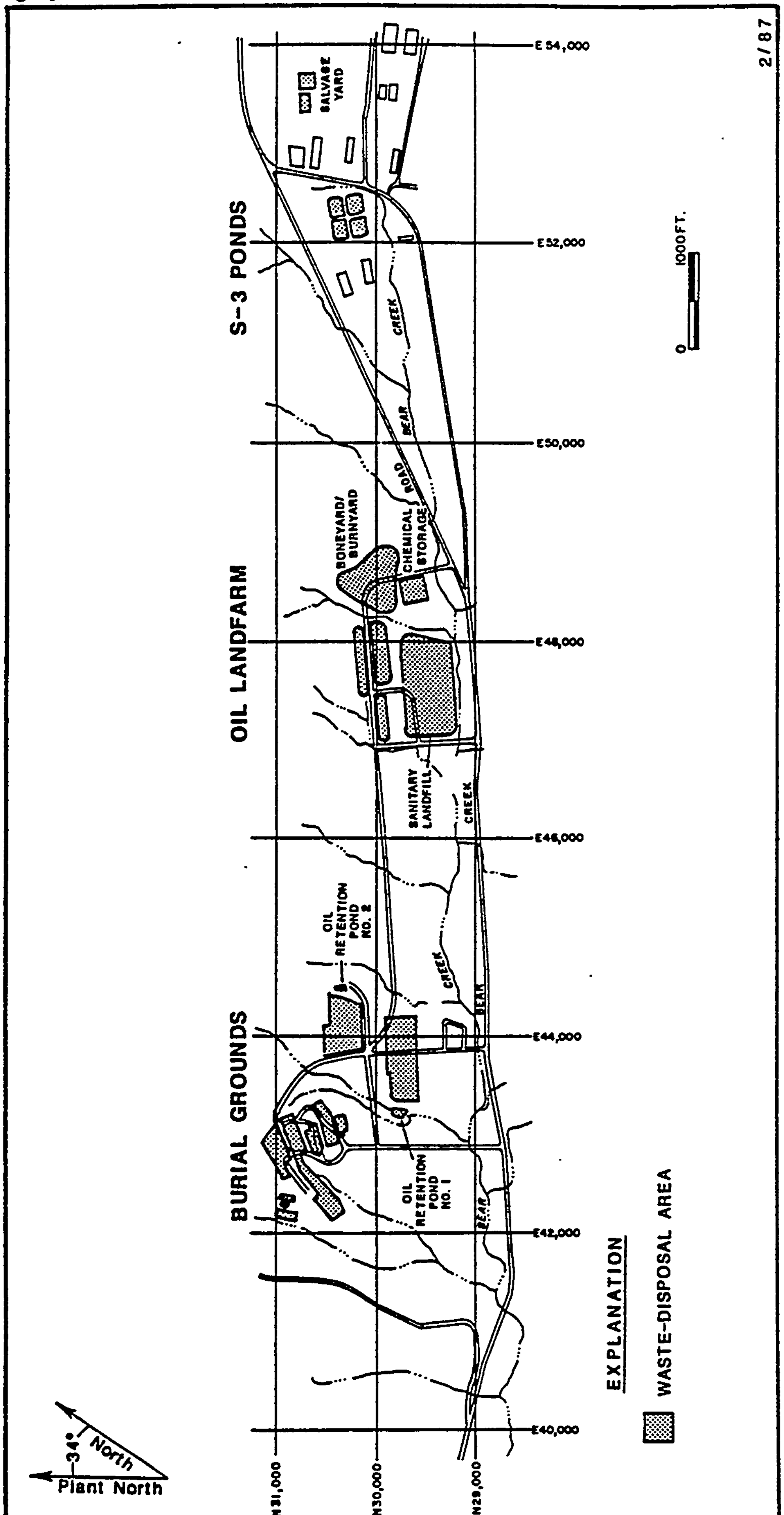

FIGURE 1-1. BEAR CREEK VALLEY WASTE DISPOSAL AREA

flow pattern suggested by potentiometric contours are believed to be highly variable because of the wide variety of controlling geologic features.

Dissolution of carbonate rock has occurred in Bear Creek Valley, and particularly beneath the channel of Bear Creek. Discharging ground water sustains the flow of Bear Creek or, at times of low flow, moves through the solution cavity system underlying Bear Creek. Some water emerges from the cavity system as springs.

1.3 OBJECTIVES

The objectives of the Phase IV Drilling Program were to: (1) evaluate the aquifer hydraulic characteristics, (2) provide data on contaminant plume migration downdip and along strike, (3) evaluate vertical hydraulic gradients, and (4) monitor cavernous zones south of the Sanitary Landfill and adjacent to Bear Creek.

The purpose of this report is to summarize the findings of the Program, present interpretations of the hydraulic conductivity tests conducted at the wells, evaluate the chemical data, and assess the impact of these evaluations on the proposed remedial-action alternatives.

2.0 FIELD INVESTIGATIONS

2.1 INSTALLATION OF PHASE IV MONITOR WELLS

During the period from April through November 1985, G&M supervised the installation of 16 monitor wells in the BCVWDA. The locations and construction details of the wells are shown in Figure 2-1 and Table 2-1, respectively. Four of the wells are located at the S-3 Ponds, two near the Oil Landfarm, five near the Sanitary Landfill, and five at the Burial Grounds. Ten of the wells monitor depths of from 40 ft to 285 ft and six of the wells monitor depths of from 460 ft to 600 ft. The wells are numbered GW-116 through GW-126 and GW-225 through GW-229.

For the purposes of this report, wells GW-116, GW-120, GW-122, GW-124, GW-126, and GW-225 through GW-229, which monitor zones less than approximately 300 ft deep, will be referred to as "shallow" or "shallow bedrock" wells. The remaining Phase IV wells, GW-117, GW-118, GW-119, GW-121, GW-123 and GW-125, which monitor zones greater than approximately 450 ft deep, will be referred to as "deep" or "deep bedrock" wells. Detailed lithologic and well-construction diagrams and hydrogeologic observations made during the Phase IV Drilling Program were submitted to Energy Systems by G&M (February 1986).

Five air-rotary drill rigs were used to install the wells: three Failing 1250s, one Failing Jed A, and one Gardner Denver 1500. The Gardner Denver 1500 rig and the

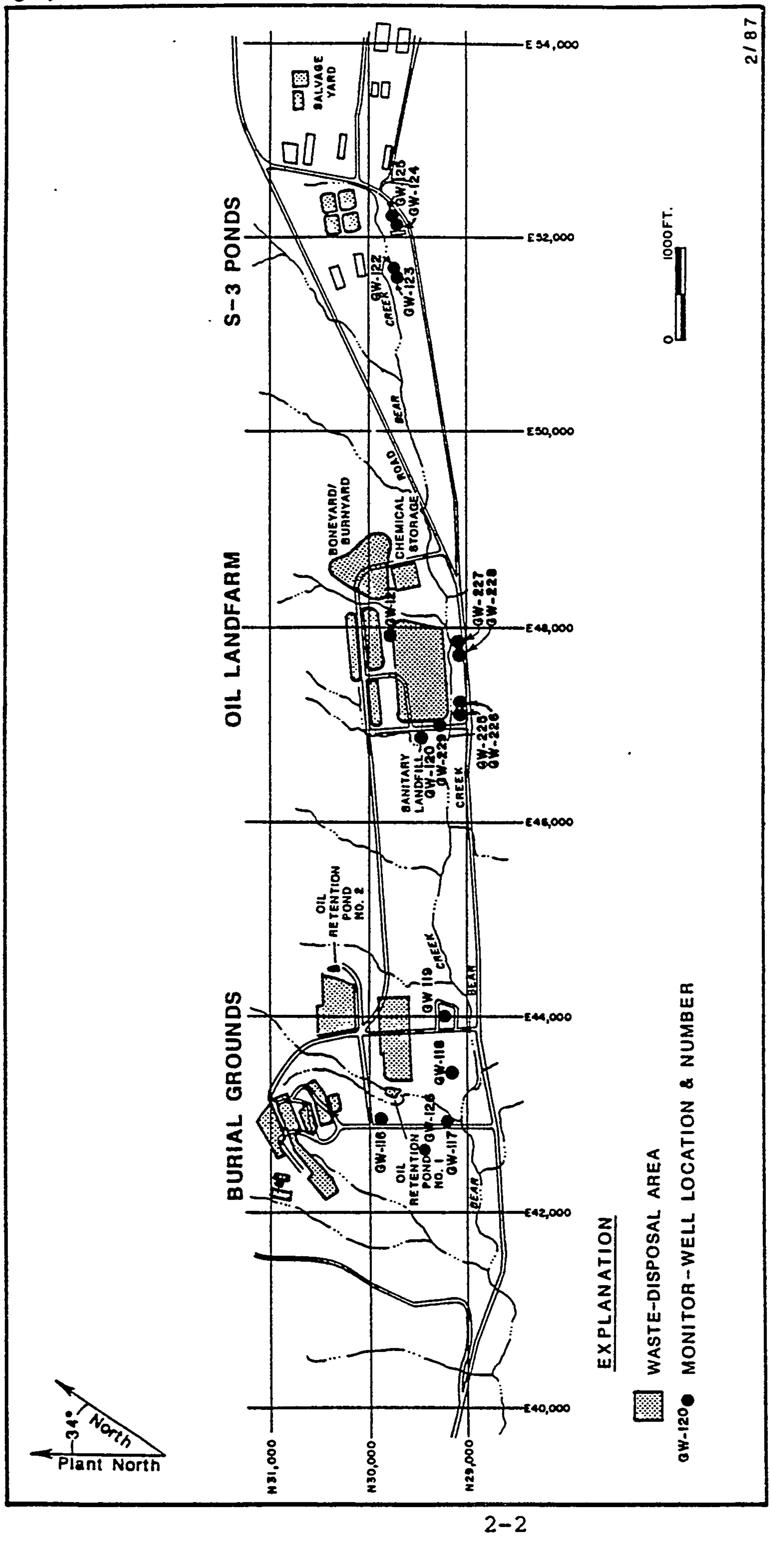

FIGURE 2-1. PHASE IV MONITOR-WELL LOCATIONS

TABLE 2-1. PHASE IV MONITOR-WELL CONSTRUCTION DATA

WELL NO.	LOCATION	COORDINATES PLANT GRID	GROUND ELEVATION (FT. MSL)	MEASURING POINT ELEVATION (FT. MSL)	UNWEATHERED BEDROCK DEPTH /FORMATION (FT.)	DEPTH OF 10-IN SURFACE CASING (FT.)	DEPTH OF 4-IN WELL CASING (FT.)	DEPTH OF OPEN INTERVAL/ FORMATION (FT.)	TOTAL DEPTH (FT.)	DATE COMPLETED
GW-116	B.G.	N29762.2 E42912.9	942.05	945.07	40.5/Єn	43.0	235	235-285/Єn	285	06/24/85
GW-117	B.G.	N29183.3 E42918.2	909.10	912.16	18.0/Єmn	19.5	480	480-530/Єn	530	06/19/85
GW-118	B.G.	N29147.4 E43404.5	909.37	912.39	15.0/Єmn	31.0	525	525-575/Єn	575	08/03/85
GW-119	B.G.	N29253.8 E44097.7	918.92	921.91	20.0/Єmn	30.0	460	460-510/Єn	510	08/02/85
GW-120	O.L.	N29455.5 E46942.5	944.19	947.27	17.0/Єn	19.0	130	130-180/Єn	180	08/25/85
GW-121	O.L.	N29798.9 E47963.6	963.46	966.57	20.0/Єn	22.0	550	550-600/Єm	600	06/19/85
GW-122	S-3	N29741.0 E51806.7	1004.15	1007.20	37.0/Єn	39.0	92	92-142/Єn	142	07/25/85
GW-123	S-3	N29741.7 E51794.2	1004.43	1007.45	38.0/Єmn	39.0	522	522-572/Єn	572	07/25/85
GW-124	S-3	N29646.1 E52207.6	1003.98	1006.85	30.0/Єmn	30.5	100	100-150/Єmn	150	07/23/85
GW-125	S-3	N29655.7 E52223.2	1003.51	1006.78	25.0/Єmn	27.0	502	502-552/Єn	552	07/22/85
GW-126	B.G.	N29361.5 E42678.7	929.02	932.06	27.0/Єn	31.0	105	105-155/Єn	155	06/24/85
GW-225	S.L.	N29155.5 E47461.3	940.21	943.11	30.0/Єmn	32.0	150	150-200/Єmn	200	10/08/85
GW-226	S.L.	N29155.5 E47472.8	940.56	943.40	28.0/Єmn	30.0	45	45-55/Єmn	55	10/14/85
GW-227	S.L.	N29172.1 E47802.0	943.91	946.46	19.0/Єmn	20.0	30	30-40/Єmn	40	11/09/85
GW-228	S.L.	N29170.8 E47790.8	943.85	946.47	24.0/Єmn	32.0	80	80-100/Єmn	100	10/23/85
GW-229	S.L.	N29256.3 E47016.5	945.71	949.00	32.0/Єmn	37.0	40	40-55/Єmn	55	10/30/85

Єmn - MAYNARDVILLE LIMESTONE
Єn - NOLICHUCKY SHALE
Єm - MARYVILLE LIMESTONE

B.G. - BURIAL GROUNDS
O.L. - OIL LANDFARM

S.L. - SANITARY LANDFILL
S-3 - S-3 PONDS

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Failing Jed A rig were used to drill a 10-in-diameter borehole for the deep bedrock wells. The three Failing 1250s were used to drill the shallow bedrock wells and the 4-in-diameter open intervals.

The principal components of the wells are a 10-in-diameter black steel surface casing, a 4-in-diameter threaded and coupled black steel inner casing, and an open-hole monitor interval. The surface casing was installed to prevent collapse of the unconsolidated material as drilling progressed. The inner casing was used to seal bedrock zones from the monitoring zone. The annular seals were emplaced by pressure grouting using Class A, Type I cement. A concrete pad was formed around each well to divert surface runoff.

To ensure well integrity, the following measures were taken during drilling and well installation:

- Drill rigs and all support equipment were thoroughly steam cleaned prior to mobilization at each site and as needed during drilling.
- No thread lubricant was used on the drill rods.
- Plumbness of wells greater than 55 ft in depth was measured at approximately 40-ft intervals, as drilling progressed, with a downhole Geolograph deviation instrument.
- Steel strap centralizers were welded to the inner casing at 75-ft intervals to ensure plumbness in the borehole.
- No chemical additives were mixed with the cement or introduced into the borhole.

2.2 DEVELOPMENT AND PRELIMINARY SAMPLING OF PHASE IV MONITOR WELLS

The wells were initially developed immediately upon completion using the air-lift method, which was continued until the well was dry or the water was sediment free. The duration of well development ranged from 30 minutes to 2-1/2 hours, averaging one hour for all wells except GW-229. Well GW-229 monitors a 12-ft solution cavity partially filled with clay and was developed for 20 hours.

Final development was conducted by G&M at wells GW-116 through GW-126 in October 1985. Well evacuation was accomplished using a Grundfos stainless steel submersible pump set near the bottom of the inner well casing with 1-1/4-in-diameter black steel riser pipe. Water pumped from the well was discharged into two large (145- and 113-gallon size) galvanized tubs from which the total volume evacuated was measured. The pump and riser pipe were thoroughly steam cleaned before proceeding to the next well location.

Samples were collected from the discharge line at the beginning, middle, and end of pumping by K-25 Laboratory (K-25) personnel for water-quality analyses. As pumping proceeded, field measurements of pH and specific conductance were recorded by G&M personnel at two-, three-, or five-minute intervals, depending on the anticipated evacuation time. Salinity and temperature were measured periodically during pumping.

The pump was shut off when the water level approached the bottom of the inner casing. Water-level measurements were taken before and after evacuation and periodically thereafter to track recovery of the wells. The recovery data were used to calculate the hydraulic conductivity of the transmissive zones supplying the wells.

3.0 AQUIFER HYDRAULIC CHARACTERISTICS

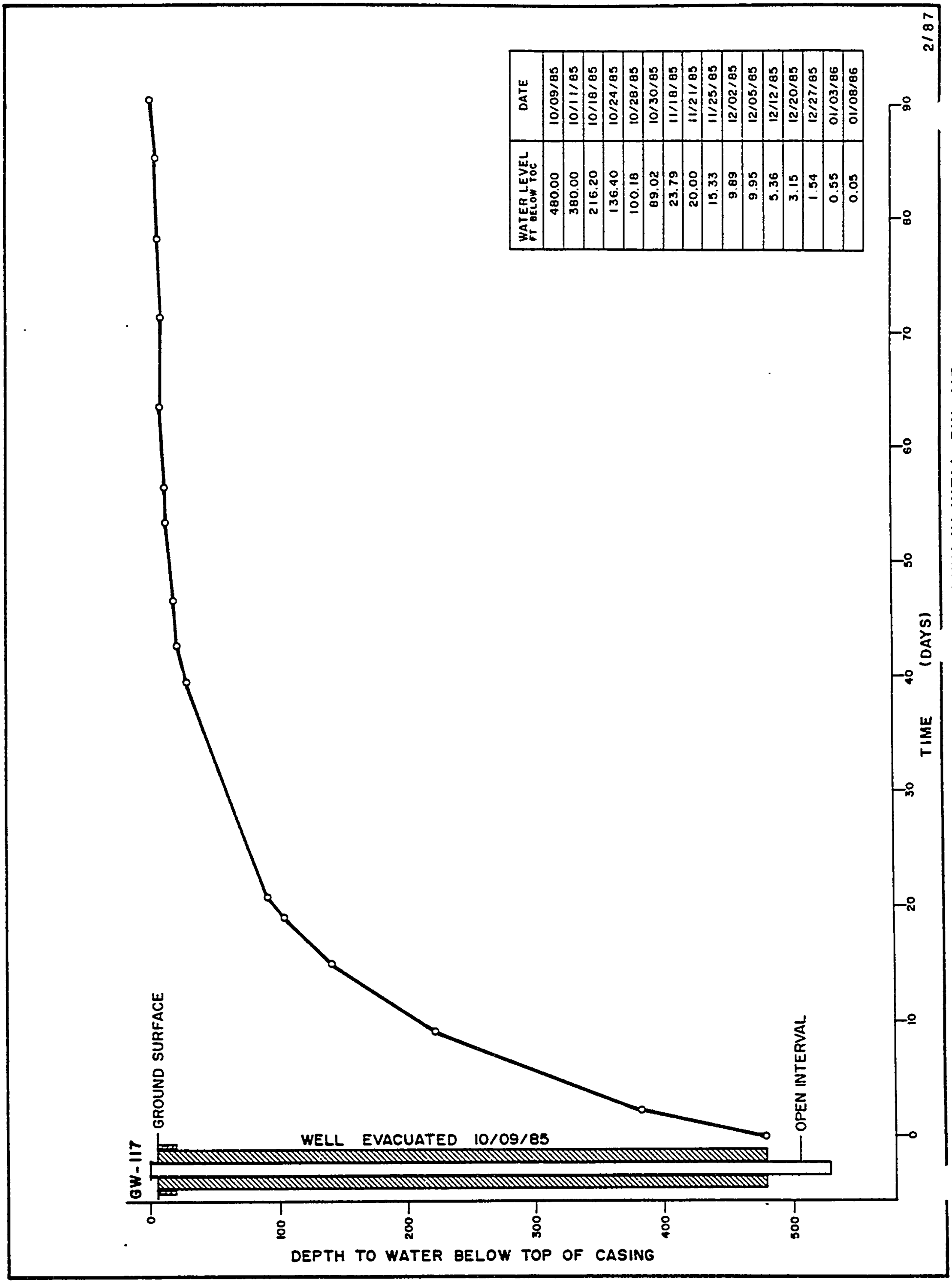
3.1 PHASE IV WATER-LEVEL RECOVERY

3.1.1 Deep Well Recovery

Measurement of water-level recovery began immediately upon completion of final development. Recovery of the deep wells (GW-117, GW-118, GW-119, GW-123, and GW-125), all of which monitor the Nolichucky Shale at depths greater than 450 ft, is very slow. The most rapid water-level recovery was observed in GW-117, in which almost all of the 480 ft of drawdown recovered to the top of the well casing in approximately 75 days. In the fall of 1986, a pressure gauge was installed on well GW-117 to quantify head and to determine if equilibrium had been reached. Figure 3-1 shows water-level recovery in well GW-117. The shape of the recovery curves for the other deep wells is very similar to GW-117 but has flatter slopes because they are open to less transmissive zones. Well GW-121 has remained dry. As indicated in Table 3-1, wells GW-118, GW-119, GW-123, and GW-125 had not completely recovered as of November 3, 1986, more than a year since the wells were evacuated.

3.1.2 Shallow Well Recovery

In marked contrast to the deep wells, recovery was rapid in the shallow Phase IV wells, GW-116, GW-120, GW-122, GW-124, and GW-126, where static water levels were reached after one day (Table 3-1). All of these wells monitor zones



WATER LEVEL FT BELOW TOC	DATE
480.00	10/09/85
380.00	10/11/85
216.20	10/18/85
136.40	10/24/85
100.18	10/28/85
89.02	10/30/85
23.79	11/18/85
20.00	11/21/85
15.33	11/25/85
9.89	12/02/85
9.95	12/05/85
5.36	12/12/85
3.15	12/20/85
1.54	12/27/85
0.55	01/03/86
0.05	01/08/86

FIGURE 3-1. WATER-LEVEL _COVERY IN WELL GW-117

Table 3-1. Results of Hydraulic Conductivity Tests, Phase IV Wells

WELL NUMBER	WELL LOCATION	TOTAL DEPTH OF WELL (ft)	DATE EVACUATED	DEPTH BELOW M.P. (11-06-86) (ft)	DURATION OF RECOVERY PERIOD (days)	HYDRAULIC CONDUCTIVITY (ft/yr)
GW-116	B.G.	285	09-13-85	21.96	1	----
GW-117	B.G.	530	10-09-85	----	75**	0.04
GW-118	B.G.	575	10-08-85	8.89	394	0.01
GW-119	B.G.	510	10-07-85	2.66	395	0.02
GW-120	O.L.	180	10-04-85	6.82	1	8
GW-121	O.L.	600	-------	----	--	----
GW-122	S-3	142	10-16-85	17.70	1	38
GW-123	S-3	572	10-16-85	10.57	386*	0.01
GW-124	S-3	150	10-11-85	20.04	1	263
GW-125	S-3	552	10-14-85	14.01	388*	0.01
GW-126	B.G.	155	09-17-85	28.83	1	4

B.G. - Burial Grounds
O.L. - Oil Landfarm
S-3 - S-3 Ponds
M.P. - Measuring Point

* Recovery not Complete;
Duration as of Measurement Date
** Water Level Recovered to Top of Well Casing

NOTE: Wells GW-225 through GW-229 are not included due to lack of early time recovery data.

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less than 300 ft deep in either the Nolichucky Shale or the Maynardville Limestone where the formations are more transmissive. Recovery curve slopes for the shallow wells are steep relative to the deep well recovery curves.

3.2 HYDRAULIC CONDUCTIVITY CALCULATIONS

The water-level recovery data for wells GW-117 through GW-126 were analyzed by the Hvorslev (1951) method to estimate the hydraulic conductivity values of the formations. The results of the calculations are shown in Table 3-1 and pertinent assumptions and calculations are shown in Appendix A. Wells GW-116 and GW-225 through GW-229 were not analyzed owing to the lack of early time recovery data, and well GW-121 was not evaluated due to its failure to yield water.

Previous hydraulic conductivity testing in wells monitoring the Nolichucky Shale and Maynardville Limestone yielded values ranging from 1 to 93 ft/yr (Bechtel, 1984; and Law, 1983). All of these wells monitor depths less than 250 ft. The hydraulic conductivities at the shallow Phase IV wells tested by G&M range from approximately 4 to 263 ft/yr, which compare favorably with results obtained from previous studies. Hydraulic conductivity values were highest at the shallow Phase IV wells, GW-122 and GW-124, screened near the contact of the Maynardville Limestone with the Nolichucky Shale, (38 and 263 ft/yr, respectively) due to the presence of fractures and associated solution cavities.

The significant differences in the duration of the recovery times between the shallow and deep wells are likewise observed in the hydraulic conductivity test results. Calculated hydraulic conductivity values at the deep bedrock wells, GW-117, GW-118, GW-119, GW-123, and GW-125, which monitor zones deeper than 450 ft, were very low, ranging from 0.01 to 0.04 ft/yr. These values are two to three orders of magnitude lower than any previously calculated for Bear Creek Valley. The decrease in hydraulic conductivity with depth may be attributed to the pressure exerted by the weight of the overlying rock material which tends to compress bedding plane laminations and fractures.

The calculated hydraulic conductivity at deep well GW-118 in the Burial Grounds was 0.01 ft/yr; this well is flanked on either side by other deep wells, where the calculated hydraulic conductivity values were 2 to 4 times higher. The presence of a steeply-dipping fracture set that strikes approximately N 12° W might account for the higher permeabilities. Wells GW-117 and GW-119, where the highest values for hydraulic conductivity at depths greater than 450 ft occur, are located near two tributaries believed to be the surface expression of this fracture system. The hydraulic conductivity at GW-117, which is located adjacent to a pronounced topographic lineament associated with one of the tributaries, was higher than at any of the other wells deeper than 450 ft. Conversely, the hydraulic conductivities at wells GW-118 (in the Burial Grounds), and GW-123 and GW-125 (south of the S-3 Ponds), are very low; these wells are not near tributaries or pronounced topographic lineaments. Field hydraulic conductivity test results from previous investigations in the Burial Grounds (Bechtel, 1984) also indicate that wells adjacent to tributaries and screened in shallower bedrock and unconsolidated zones have higher permeability values.

4.0 WATER-QUALITY SAMPLING OF THE PHASE IV WELLS

4.1 SAMPLING HISTORY

The sampling history has been influenced by the time frame in which each well was completed, the inadequacy of standard sampling protocols to obtain representative samples, and the locations of the wells with respect to the contaminant plumes. A synoposis of the sampling episodes is presented in Table 4-1. Wells GW-116 through GW-126, which were completed during the summer months, were all sampled during final well development in September and October 1985. The objective of this sampling round was to obtain a preliminary indication of the ground-water quality in the newly installed Phase IV wells at the earliest possible time and to determine which well should be incorporated into the quarterly sampling network. The remaining wells, GW-225 through GW-229, were not sampled in October because they were either not completed or were not developed. All of the shallow wells except GW-122 and GW-124 were included in sampling programs conducted during subsequent quarters.

4.2 OCTOBER 1985 PHASE IV GROUND-WATER SAMPLING PROTOCOL

Strict adherence to accepted well sampling protocol was not observed for several reasons. For example, the accepted practice of well evacuation prior to sampling would not yield representative ground-water samples from deep wells GW-117, GW-118, GW-119, GW-123, and GW-125, because recovery in these

TABLE 4-1. SAMPLING HISTORY FOR PHASE IV WELLS

WELL NUMBER	QUARTER SAMPLED/LABORATORY						
	SEPT/OCT 85* K-25	JAN 86 WESTON	JAN 86 K-25	MAY 86 WESTON	MAY 86 K-25	AUG/SEPT 86 WESTON	AUG/SEPT 86 K-25
116	M,V,Misc.	M,V,Misc.		M,Misc.		M,V,Misc.	
117	M,V,Misc.						
118	M,V,Misc.						
119	M,V,Misc.						
120	M,V,Misc.	M,V,Misc.		M,V,Misc.		M,Misc.	
122	M,V,Misc.					M,V,Misc.	
123	M,V,Misc.						
124	M,V,Misc.					M,V,Misc.	
125	M,V,Misc.						
126	M,V,Misc.	M,V,Misc.		M,Misc.		M,V,Misc.	
225		M,V,Misc.	M,V,Misc.	M,V,Misc.	M,V,Misc.	M,V,Misc.	M,V,Misc.
226		M,V,Misc.	M,V,Misc.	M,V,Misc.	M,V,Misc.	M,V,Misc.	M,V,Misc.
227		M,V,Misc.	M,V,Misc.	M,V,Misc.	M,V,Misc.	M,V,Misc.	M,V,Misc.
228		M,V,Misc.	M,V,Misc.	M,V,Misc.	M,V,Misc.	M,V,Misc.	M,V,Misc.
229		M,V,Misc.	M,V,Misc.	M,V,Misc.	M,V,Misc.	M,V,Misc.	M,V,Misc.

M = Metals
V = VOCs
Misc. = All or part of the following parameters: chloride, nitrate, sulfate, pH, conductivity, gross alpha, gross beta, TOC, TOX, TSS

* Samples not collected in accordance with accepted sampling protocol.

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wells would take place as seepage from the entire 50-ft open interval over an extended period of time. This process of seepage recharge coupled with the rapid decrease in hydrostatic pressure, which would result from well evacuation, could cause significant aeration and degassing of the water sample. Further, because it is not possible to completely and instantaneously evacuate all water from the well, the first water available for sampling would be residual water that had clung to the sides of the casing and open hole during pumping. For these reasons, it was recommended that the deep wells not be included in the quarterly monitor-well sampling scheme until an acceptable protocol could be formulated and appropriate sampling equipment obtained.

Other significant deviations from accepted protocol were sampling from a submersible pump, sampling stagnant water from the well casing, and the absence of field or trip blanks for quality assurance. Sampling from a submersible pump will cause agitation of the water sample, resulting in possible aeration of the sample. Stagnant water in the well casing may not be representative of formation water due to the potential for alterations in the concentration of pH-sensitive parameters. Because neither field nor trip blanks were taken, it cannot be verified that accidental contamination of the samples from sampling error did not occur.

5.0 GROUND-WATER QUALITY

5.1 BACKGROUND

5.1.1 Sources of Data

G&M received the chemical analyses results from the sampling of the Phase IV wells by K-25 in October 1985 from Energy Systems. H&R Technical Associates (H&R) provided the remainder of the data, including sampling by both K-25 and Roy F. Weston, Inc., (Weston) from the SAS database. The results are final for October 1985 and January 1986 sampling events. The data from May 1986 have been reviewed but have not been issued as a final report at this time. The first draft of chemical results from the August 1986 sampling was released to a limited distribution for technical review in December 1986. G&M has reported to H&R any anomalous values found during the compilation of this report and these have either been corrected or substantiated. The chemical results of the Phase IV well sampling are summarized by site in Appendix B.

5.1.2 Water-Quality Standards

G&M has evaluated ground water quality based on standards of TDHE rules, Chapter 1200-1-11-.05(6)(c)2(i)(ii) and (iii). These standards include EPA Interim Primary Drinking-Water Standards and parameters indicating ground-water quality and contamination as shown in Appendix C. Of these, endrin, lindane, methoxychlor, toxaphene, [2,4-D], [2,4,5-TP Silver], radium, and coliform bacteria were not evaluated because these constituents were not utilized at the Plant and are not a part of the waste stream.

5.1.3 Summation of VOCs

Ground-water samples were analyzed for the Priority Pollutant Volatile Organic Compounds (VOCs) listed in Appendix D. The concentrations of VOCs were summed for the purposes of this report. VOCs detected at a concentration too low to be quantified were assumed to be one-half the quantitation limit. Reported values that were in excess of the calibration range were assumed to be correct and summed.

5.2 EVALUATION OF OCTOBER 1985 CHEMICAL DATA

Interpretation of the October 1985 chemical data is complicated by the preliminary nature of data from the deep wells and the tendency of the Inductively Coupled Plasma Emission Spectroscopy (ICP) method to yield erroneously high values for certain metals. As shown in Table 4-1, the only chemical data available for the deep wells, GW-117, GW-118, GW-119, GW-123, and GW-125, were obtained during the October 1985 sampling. The data from subsequent quarterly sampling episodes were collected in accordance with accepted protocol and metals were analyzed by the Atomic Adsorption Spectroscopy (AAS) method.

To evaluate the reliability of the October 1985 data, G&M compared these data for wells GW-116, GW-120, GW-122, GW-124, and GW-126, with data from subsequent sampling episodes of these wells. The comparison focused on those parameters which exceeded the standards listed in Appendix C and the VOCs listed in Appendix D.

5.2.1 Metals

Elevated levels of chromium ranging from 0.16 to 0.26 mg/L were found in excess of the EPA drinking-water standard of 0.05 mg/L in samples collected in October 1985 from all of the Phase IV wells. The chromium concentrations reported for the May and September 1986 samples from wells GW-116, GW-120, GW-122, GW-124, and GW-126 were less than 0.01 mg/L. These samples were analyzed using the more accurate AAS method, indicating that (1) the elevated levels of chromium were due to interferences and (2) ground-water is not contaminated by chromium at the Phase IV well locations.

A comparison of analyses of barium by the ICP and the AAS methods in wells GW-116, GW-120, and GW-126 shows good agreement in the values obtained using the ICP and the AAS methods of analyses, indicating that the ICP method gives reliable results for that constituent.

Arsenic was not tested in October 1985 and the remaining EPA drinking-water metals, cadmium, lead, mercury, selenium, and silver, generally had detection limits above the drinking-water standard.

5.2.2 Nitrates

The October 1985 nitrate samples were analyzed by either: ion chromatography, reported by K-25 as nitrate nitrogen, or cadmium reduction, reported by Weston as nitrate/nitrite nitrogen. In May 1986, Weston analyzed wells GW-116 and GW-126 by ion chromatography and reported total nitrate. The effect of using one or the other of these methods is not evident from the data, except that the cadmium reduction results are reported with lower detection limits, 0.05 as opposed to 1.0. Nitrite is not believed to be present in sufficient amounts to invalidate the reporting of nitrate concentrations as nitrate/nitrite nitrogen.

The sampling procedures employed in October 1985 could have caused the values for nitrate concentration to be artifically high. This is suggested by the data from well GW-116, located in the Burial Grounds, which is far from the nitrate plume. In that well, the concentration dropped from 3.2 mg/L in October 1985 to 0.06 mg/L in Janaury 1986, and the concentration has remained below the detection limit through August 1986. A decrease in the concentration of nitrate by almost an order of magnitude from October 1985 to January 1986 also was noted in well GW-120. A decrease of similar magnitude was noted in well GW-120 from January to May 1986 after the sampling protocol had been standardized. This latter anomaly could be the result of a reporting error and additional sampling will be required to identify the more correct value.

Wells GW-122 and GW-124 are the only wells in an area of possible nitrate contamination which were sampled in October 1985 and again during the regular quarterly sampling in August 1986. Both of these wells exhibited substantial decreases in nitrate concentration from October 1985 to September 1986. The October 1985 nitrate analyses by K-25 are on the order of four times higher than in August 1986, suggesting the possibility that the October 1985 data were reported as total nitrate. However, K-25 confirmed these values to be nitrate nitrogen (personal communication, Marsha Lindauer, December 31, 1986). Well GW-122 dropped from 1,600 to 495 mg/L and GW-124 dropped from 1,700 to 300 mg/L, supporting the contention that samples collected from the October 1985 sampling may display anomalously high values of nitrate concentration.

5.2.3 VOCs

VOCs were not detected in samples from wells GW-116, W-120, and GW-126 taken in October 1985. In subsequent sampling of these wells, the only VOC reported was methylene chloride (<10 ug/L), which was attributed to laboratory contamination. GW-124 is the only Phase IV well sampled where the ground water contained measurable VOCs in October 1985 and in a subsequent sampling event; the concentration of VOCs ranged from 17 to 33 ug/L in October 1985 and was reported at 51 ug/L in August 1986. This suggests that sampling through the submersible pump had little or no effect on the concentrations of tetrachloroethene (PCE) and trichloroethene (TCE), in the water samples.

5.3 CONTAMINATION IN THE PHASE IV WELLS

5.3.1 S-3 Ponds

Phase IV wells GW-122, GW-123, GW-124, and GW-125 form two well clusters at the S-3 Ponds, as shown on Figure 2-1. Wells GW-122 and GW-124 monitor shallow bedrock zones near the contact of the Maynardville Limestone and the Nolichucky Shale, whereas wells GW-123 and GW-125 monitor deep zones in the Nolichucky Shale.

Barium concentrations in excess of the drinking-water standard were found in ground water from shallow wells GW-122 and GW-124. Elevated values of chromium reported for only the October 1985 sampling. Fluoride was detected above the drinking-water standard in samples from wells GW-122 and GW-123 in October 1985. The occurrence of fluoride in ground water from one well cluster open to zones separated by hundreds of vertical feet yet not detected in ground water from another well cluster monitoring similar zones seems unlikely.

Nitrate was detected in elevated concentrations in ground water samples from each of the Phase IV wells. The concentrations in samples from wells GW-122 and GW-124 were 495 mg/L and 300 mg/L, respectively, in September 1986. The October 1985 data indicated the presence of nitrate in elevated concentrations at the deep well locations; however, these data are believed to have been biased by the sampling technique.

VOCs were detected in samples from three wells, GW-123, GW-124, and GW-125, during the October 1985 sampling. Concentrations of summed VOCs ranged from 6 to 29 ug/L in the samples from deep wells, GW-123 and GW-125, where the primary constituent was toluene with PCE noted in two of the five samples. In the sample from well GW-124, summed VOCs ranged from 17 to 33 ug/L in October 1985. The primary constituents in ground water were TCE and PCE; no toluene was detected. The September 1986 sampling confirms the presence of these consitutents in very low concentrations in ground water from well GW-124.

5.3.2 Oil Landfarm

As shown on Figure 2-1, two well clusters, GW-225 and GW-226 along with GW-227 and GW-228, are located at the southern perimeter of the Sanitary Landfill; wells GW-229 and GW-120 are located west of the Sanitary Landfill; and well GW-121 is located at the southern perimeter of the Oil Landfarm. GW-121 was drilled to a depth of 600 ft and has not yielded adequate water for sampling.

Wells GW-225 through GW-229 were selected by Energy Systems for duplicate sampling and analysis by both Weston and K-25 for quality-control purposes. The data from both samplings are included in Appendix B. While a detailed analysis of these data from a quality-control standpoint is beyond the scope of this report, fundamental observations are presented as necessary to complete data interpretation.

Barium was the only metal found at concentrations approaching the EPA drinking-water standard. Barium was reported in a single well sample, GW-229, at concentrations slightly above the drinking-water standard by K-25 and Weston, 1.1 and 1.3 mg/L, respectively, during the January 1986 sampling on which ICP analyses were conducted. Subsequent sampling in May and September 1986 and analysis by AAS show concentrations below the drinking-water standard but elevated above background as defined by upgradient wells GW-43, GW-44, and GW-84 which ranged from 0.18 to 0.32 mg/L during the same time period.

Nitrates were found in samples from clustered wells GW-225 through GW-228 at concentrations exceeding the EPA drinking-water standard, ranging from 23 to 72 mg/L from January through September 1986. Ground water samples from well GW-226 contained nitrates at levels only slightly above the standard.

VOCs were not detected in the sample from well GW-120 but were present in the remaining samples collected both by Weston and K-25. The percent agreement in the summed VOC concentrations reported by the two laboratories ranged from 89% to 29% and averaged 69%. The Weston values were higher in every case except two. G&M utilized the Weston data in the interpretations discussed herein because they represent a conservative estimation of the contaminant plume.

The concentration of VOCs ranged from a low of 35 ug/L in Janaury 1986 at well GW-229 to a high of 866 ug/L in May 1986 at well GW-225. In samples from wells GW-225 through GW-228, TCE is almost solely responsible for the entire summed VOC concentration. GW-225 is the deepest of the wells sampled, 200 ft, and has consistently higher concentrations of summed VOCs than the other wells. GW-227, screened in a shallow cavernous zone, has the lowest concentrations of the clustered wells south of the Sanitary Landfill.

The ground water samples from GW-229 also have very low concentrations of summed VOCs, 35 to 65 ug/L, but most notably, the constituents are markedly different from those present in samples from clustered wells GW-225 through GW-228. In samples from well GW-229, TCE is present at very low levels and a major portion of the summed concentrations are composed of constituents detected below the quantitation limit. The two compounds commonly detected above the quantitation limit are trans-1,2-dichloroethene and vinyl chloride, which ranged in concentration from <10 to 25 ug/L.

Samples from wells GW-226 and GW-229 exceeded the standard for gross alpha only in January 1986 and only according to the results of the K-25 sampling. Subsequent quarterly sampling by both laboratories through September

1986 have not yielded values above the standard. Samples from well GW-227 have consistently exceeded the standard for gross alpha since sampling began in January 1986, with concentrations ranging from 24 to 132 pCi/L.

5.3.3 Burial Grounds

Neither metals nor nitrate contamination was noted in samples from any of the Phase IV wells in the Burial Grounds (Figure 2-1). The occurrence of fluoride above the drinking-water standard in samples from wells GW-117 and GW-119 in the October 1985 sampling cannot be explained or even substantiated with the available data.

Samples from wells GW-116, GW-119, and GW-126 do not show significant contamination by VOCs. Toluene was the only VOC present in the samples from well GW-118; toluene concentration ranged from not detected (ND) to 16 ug/L in the four samples collected in October 1985. The only Phase IV well in the Burial Grounds to indicate VOC contamination in the ground water was at GW-117, where the summed concentration ranged from 7,077 ppb to 8,176 ppb in October 1985.

Authors Note: The Phase IV wells were added to the assessment monitor-well network for quarterly sampling. Thus, a more accurate determination of the water-quality in these wells will be presented in the annual assessment report for 1987 to be submitted to the TDHE.

6.0 REMEDIAL IMPLICATIONS

6.1 HYDROGEOLOGIC ASPECTS

The information derived from the installation and testing of the Phase IV monitor wells has important implications with regard to selection of remedial alternatives. The very slow recovery of water levels in the deep wells and the low permeability of the formations at depths greater than 450 ft indicate that it would be impractical to attempt to recover a significant amount of contaminated water from those depths.

6.2 WATER-QUALITY ASPECTS

The chemical data from the shallow Phase IV wells at the S-3 Ponds indicate the presence of nitrate in excess of the EPA drinking-water standard south of Bear Creek in the Maynardville Limestone formation. Nitrate data from the deep Phase IV wells were biased by the sampling technique but suggest that nitrate concentrations in ground water probably exceed the EPA drinking-water standard. However, all of the concentrations were below the 1,000 mg/L level upon which G&M based the remedial design in the June 1985 report of remedial alternatives. Should the decision be made to extend ground-water remediation to include ground water having less than 1,000 mg/L, expansion of the recovery-well network would be required.

The Phase IV wells south of the Sanitary Landfill at the Oil Landfarm showed elevated concentrations of VOCs but these had been anticipated during conception of the remedial alternatives and will not require modification of the proposed measures (G&M, June 1985).

Phase IV wells in the Burial Grounds provided data to delineate the extent of the volatile organic plume to the west along strike and to the south down dip. VOCs were found in samples from deep well GW-117; however, this appears to be an isolated occurrence possibly related to the presence of a fracture zone.

6.3 RECOMMENDED MODIFICATIONS TO REMEDIAL-ACTION PLANS

Preliminary analysis of data obtained from deep wells installed in Bear Creek Valley indicates that no significant changes to the remedial-action plans will be necessary. Although contaminants were detected in the ground water at depths greater than 500 ft in the Burial Grounds and at the S-3 Ponds, the low permeability of the aquifer make recovery of the ground water impractical. The minute amounts of ground water at depths greater than 500 ft in the Oil Landfarm indicated by well GW-121 suggest that no changes in the proposed remedial-action alternatives are necessary for the Oil Landfarm.

7.0 REFERENCES

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APPENDIX A

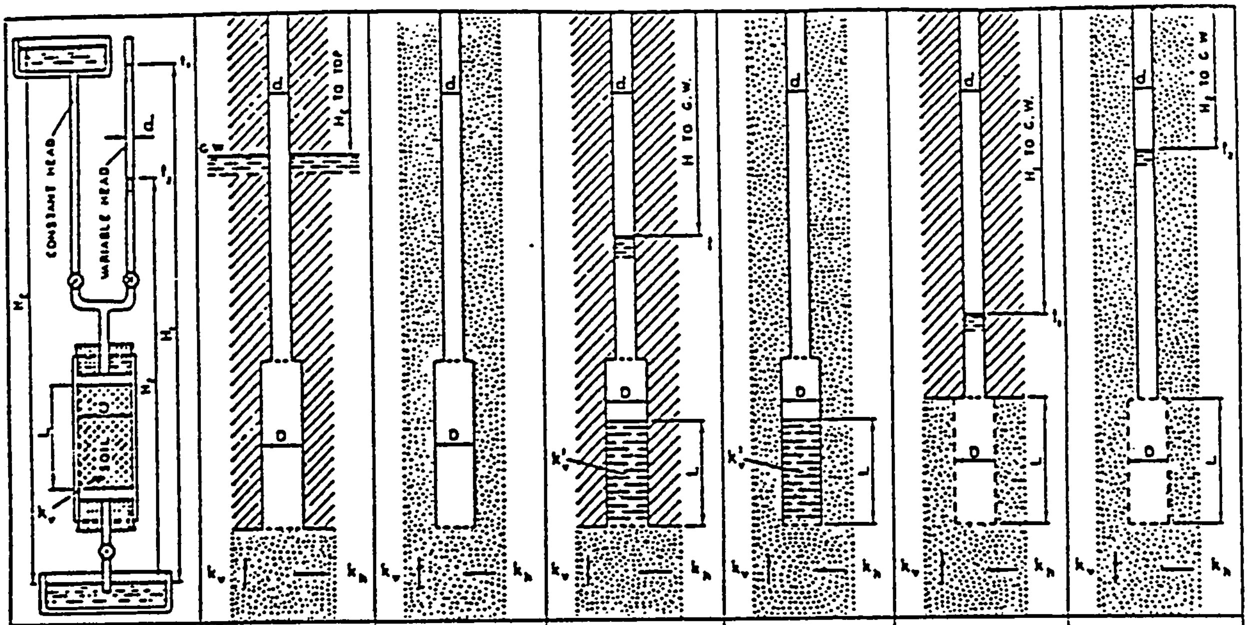
ASSUMPTIONS AND CALCULATIONS UTILIZED TO EVALUATE THE HYDRAULIC CONDUCTIVITY OF PHASE IV WELLS BY THE HVORSLEV METHOD

APPENDIX A

ASSUMPTIONS AND CALCULATIONS UTILIZED TO EVALUATE THE HYDRAULIC CONDUCTIVITY OF PHASE IV WELLS BY THE HVORSLEV METHOD

The hydraulic conductivity evaluations were determined by a method developed by Hvorslev (1951). The method assumes that Darcy's Law is valid, soil and water are incompressible, and artesian conditions prevail. Seven cases, labeled A through G on Figure A-1, are presented depending upon the hydrogeologic conditions and the configuration of the well. Case G was selected as most representive and the equation for variable head, where $mL/D>4$, was utilized. The variable names are defined on Figure A-1 under "NOTATION" and the values of each variable for a given well are presented in Table A-1. Note the values for d, D, m, L, and t_o are assumed to be the same for every well. The values for d, D, and L are metric conversions of nominal casing and hole diameters and open interval lengths; thus, the preciseness of the metric values does not reflect the level of accuracy of the nominal values.

Hydraulic conductivity is a function of the change in head from H_1 to H_2 over the time period t_1 to t_2 with more rapid changes in head resulting in higher values of hydraulic conductivity.



A	B	C	D	E	F	G
LABORATORY PERMEAMETER (CONSOLIDOMETER)	FLUSH BOTTOM AT IMPERVIOUS BOUNDARY	FLUSH BOTTOM IN UNIFORM SOIL	SOIL IN CASING AT IMPERVIOUS BOUNDARY	SOIL IN CASING IN UNIFORM SOIL	WELL POINT-FILTER AT IMPERVIOUS BOUNDARY	WELL POINT-FILTER IN UNIFORM SOIL

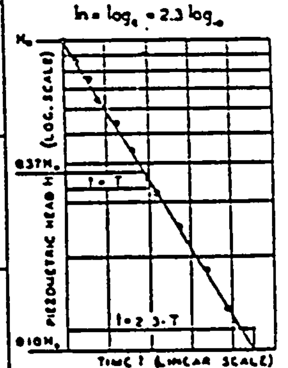
CASE	CONSTANT HEAD	VARIABLE HEAD	BASIC TIME LAG
A	$k_v = \frac{4 \cdot q \cdot L}{\pi \cdot D^2 H_c}$	$k_v = \frac{d^2 \cdot L}{D^2 \cdot (t_2 - t_1)} \ln \frac{H_1}{H_2}$ $k_v = \frac{L}{t_2 - t_1} \ln \frac{H_1}{H_2}$ FOR $d = D$	$k_v = \frac{d^2 \cdot L}{D^2 \cdot T}$ $k_v = \frac{L}{T}$ FOR $d = D$
B	$k_m = \frac{q}{2\ D \cdot H_c}$	$k_m = \frac{\pi \cdot d^2}{8 \cdot D \cdot (t_2 - t_1)} \ln \frac{H_1}{H_2}$ $k_m = \frac{\pi \cdot D}{8 \cdot (t_2 - t_1)} \ln \frac{H_1}{H_2}$ FOR $d = D$	$k_m = \frac{\pi d^2}{8 \cdot D \cdot T}$ $k_m = \frac{\pi \cdot D}{8 \cdot T}$ FOR $d = D$
C	$k_m = \frac{q}{2.75 \cdot D\ H_c}$	$k_m = \frac{\pi \cdot d^2}{11 \cdot D \cdot (t_2 - t_1)} \ln \frac{H_1}{H_2}$ $k_m = \frac{\pi \cdot D}{11 \cdot (t_2 - t_1)} \ln \frac{H_1}{H_2}$ FOR $d = D$	$k_m = \frac{\pi \cdot d^2}{11 \cdot D \cdot T}$ $k_m = \frac{\pi \cdot D}{11 \cdot T}$ FOR $d = D$
D	$k_v' = \frac{4 \cdot q \left[\frac{\pi}{8} \cdot \frac{k_v'}{k_v} \cdot \frac{D}{m} + L\right]}{\pi \cdot D^2\ H_c}$	$k_v' = \frac{d^2 \cdot \left[\frac{\pi}{8} \cdot \frac{k_v'}{k_v} \cdot \frac{D}{m} + L\right]}{D^2 \cdot (t_2 - t_1)} \ln \frac{H_1}{H_2}$ $k_v = \frac{\frac{\pi}{8} \cdot \frac{D}{m} + L}{t_2 - t_1} \ln \frac{H_1}{H_2}$ FOR $k_v' = k_v$, $d = D$	$k_v' = \frac{d^2 \cdot \left[\frac{\pi}{8} \cdot \frac{k_v'}{k_v} \cdot \frac{D}{m}\right] + L}{D^2 \cdot T}$ $k_v = \frac{\frac{\pi}{8} \cdot \frac{D}{m} + L}{T}$ FOR $k_v' = k_v$, $d = D$
E	$k_v' = \frac{4 \cdot q \left[\frac{\pi}{11} \cdot \frac{k_v'}{k_v} \cdot \frac{D}{m} + L\right]}{\pi\ D^2\ H_c}$	$k_v' = \frac{d^2 \cdot \left[\frac{\pi}{11} \cdot \frac{k_v'}{k_v} \cdot \frac{D}{m} + L\right]}{D^2 \cdot (t_2 - t_1)} \ln \frac{H_1}{H_2}$ $k_v = \frac{\frac{\pi}{11} \cdot \frac{D}{m} + L}{t_2 - t_1} \ln \frac{H_1}{H_2}$ FOR $k_v' = k_v$, $d = D$	$k_v' = \frac{d^2 \cdot \left[\frac{\pi}{11} \cdot \frac{k_v'}{k_v} \cdot \frac{D}{m} + L\right]}{D^2 \cdot T}$ $k_v' = \frac{\frac{\pi}{11} \cdot \frac{D}{m} + L}{T}$ FOR $k_v' = k_v$, $d = D$
F	$k_h = \frac{q \ln \left[\frac{2mL}{D} + \sqrt{1 + \left(\frac{2mL}{D}\right)^2}\right]}{2 \cdot \pi \cdot L \cdot H_c}$	$k_h = \frac{d^2 \cdot \ln \left[\frac{2mL}{D} + \sqrt{1 + \left(\frac{2mL}{D}\right)^2}\right]}{8 \cdot L \cdot (t_2 - t_1)} \ln \frac{H_1}{H_2}$ $k_h = \frac{d^2 \cdot \ln \left(\frac{4mL}{D}\right)}{8\ L \cdot (t_2 - t_1)} \ln \frac{H_1}{H_2}$ FOR $\frac{2mL}{D} > 4$	$k_h = \frac{d^2 \cdot \ln \left[\frac{2mL}{D} + \sqrt{1 + \left(\frac{2mL}{D}\right)^2}\right]}{8 \cdot L \cdot T}$ $k_h = \frac{d^2 \cdot \ln \left(\frac{4mL}{D}\right)}{8 \cdot L \cdot T}$ FOR $\frac{2mL}{D} > 4$
G	$k_h = \frac{q \ln \left[\frac{mL}{D} + \sqrt{1 + \left(\frac{mL}{D}\right)^2}\right]}{2\ \pi\ L \cdot H_c}$	$k_h = \frac{d^2 \cdot \ln \left[\frac{mL}{D} + \sqrt{1 + \left(\frac{mL}{D}\right)^2}\right]}{8 \cdot L \cdot (t_2 - t_1)} \ln \frac{H_1}{H_2}$ $k_h = \frac{d^2 \cdot \ln \left(\frac{2mL}{D}\right)}{8\ L \cdot (t_2 - t_1)} \ln \frac{H_1}{H_2}$ FOR $\frac{mL}{D} > 4$	$k_h = \frac{d^2 \cdot \ln \left[\frac{mL}{D} + \sqrt{1 + \left(\frac{mL}{D}\right)^2}\right]}{8 \cdot L \cdot T}$ $k_h = \frac{d^2 \cdot \ln \left(\frac{2mL}{D}\right)}{8 \cdot L \cdot T}$ FOR $\frac{mL}{D} > 4$

NOTATION

D = DIAM., INTAKE, SAMPLE, CM
d = DIAMETER, STANDPIPE, CM
L = LENGTH, INTAKE, SAMPLE, CM.
H_c = CONSTANT PIEZ. HEAD, CM
H_1 = PIEZ. HEAD FOR $t = t_1$, CM
H_2 = PIEZ. HEAD FOR $t = t_2$, CM
q = FLOW OF WATER, CM³/SEC.
t = TIME, SEC.
T = BASIC TIME LAG, SEC.
k_v' = VERT. PERM. CASING, CM/SEC.
k_v = VERT. PERM. GROUND, CM/SEC.
k_h = HORZ. PERM. GROUND, CM/SEC.
k_m = MEAN COEFF. PERM., CM/SEC.
m = TRANSFORMATION RATIO

$k_m = \sqrt{k_h \cdot k_v}$ $m = \sqrt{k_h / k_v}$

$\ln = \log_e = 2.3 \log_{10}$



DETERMINATION BASIC TIME LAG T

(From Hvorslev, 1951)

ASSUMPTIONS

SOIL AT INTAKE, INFINITE DEPTH AND DIRECTIONAL ISOTROPY (k_v AND k_h CONSTANT) - NO DISTURBANCE, SEGREGATION, SWELLING OR CONSOLIDATION OF SOIL - NO SEDIMENTATION OR LEAKAGE - NO AIR OR GAS IN SOIL, WELL POINT, OR PIPE - HYDRAULIC LOSSES IN PIPES, WELL POINT OR FILTER NEGLIGIBLE

FIGURE A-1. FORMULAS FOR DETERMINATION OF PERMEABILITY

Table A-1. Data Utilized for the Calculation of Hydraulic Conductivity in the Phase IV Wells

WELL NUMBER	d (cm)	D (cm)	m	L (cm)	t_1 (sec)	t_2 (sec)	H_1 (cm)	H_2 (cm)	HYDRAULIC CONDUCTIVITY (ft/yr)
GW-117	10.16	10.16	1	1524	0	5,529,600	14,630	152	0.04
GW-118	10.16	10.16	1	1524	0	5,788,800	16,002	5,724	0.01
GW-119	10.16	10.16	1	1524	0	5,788,800	13,868	1,433	0.02
GW-120	10.16	10.16	1	1524	0	28,800	321	3	8
GW-122	10.16	10.16	1	1524	0	4,800	1,937	50	38
GW-123	10.16	10.16	1	1524	0	4,406,400	15,850	7,772	0.01
GW-124	10.16	10.16	1	1524	0	930	959	7	263
GW-125	10.16	10.16	1	1524	0	5,097,600	15,027	14,706	0.01
GW-126	10.16	10.16	1	1524	0	32,400	2,560	244	4

R11-02-87Ba

APPENDIX B

CHEMICAL ANALYSES OF GROUND WATER FROM PHASE IV MONITOR WELLS

B.1 S-3 PONDS

B.2 OIL LANDFARM

B.3 BURIAL GROUNDS

KEY TO APPENDIX B

ICP = Inductively coupled plasma emission spectroscopy analysis

AAS = Atomic Adsorbtion spectroscopy analysis

UNFILTERED = Samples which were not filtered before chemical analysis

FILTERED = Samples which were filtered before chemical analysis

SAMPLE #1 = First sample taken during well evacuation, August 1985 (number denotes consecutive sample order)

ND = Not detected

- = Not tested

(LT) = Sample for which all summed VOCs were below quantitation limits

* = Sample concentrations determined by ICP method

(N) = Nitrate only

(T) = Total Nitrate

ppm = Parts per million

ppb = Parts per billion

umhos/cm = Micromhos per centimeter

pCi/l = Picocuries per liter

APPENDIX B.1

S-3 PONDS WELLS

GW-122

GW-123

GW-124

GW-125

CHEMICAL ANALYSIS OF GROUND WATER FROM
PHASE VI MONITOR WELLS IN THE S-3 POND AREA

QUARTER SAMPLED				OCT. '85			SEPT. '86
LABORATORY				K-25			WESTON
TYPE ANALYSIS FOR METALS				UNFILTERED ICP			FILTERED AAS
WELL NUMBER	PARAMETER	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4	SAMPLE #5	
GW-122	EPA INTERIM PRIMARY DRINKING WATER STANDARD						
	Arsenic (ppm)	-	-	-	-	-	<.01
	Barium (ppm)	1.0	4.8	6.1	6.0	6.0	27
	Cadmium (ppm)	<0.030	<0.030	<0.030	<0.030	<0.030	<.0025
	Chromium (ppm)	0.17	0.22	0.20	0.24	0.20	<.01
	Lead (ppm)	1.3	<0.50	<0.50	<0.50	<0.50	<.005
	Mercury (ppm)	-	-	-	-	-	<.0002
	Selenium (ppm)	-	-	-	-	-	<.01
	Silver (ppm)	<0.060	<0.060	<0.060	<0.060	<0.060	<.01
	Nitrate/Nitrite as N (ppm)	-	-	-	-	(N) 1600	495
	Fluoride (ppm)	-	-	-	-	53	-
	Gross Alpha (pCi/l)	-	-	-	-	-	<5
	Gross Beta (pCi/l)	-	-	-	-	-	<4
	GROUND-WATER QUALITY PARAMETERS						
	Manganese (ppm)	2.3	0.97	0.22	0.18	0.19	<.5^
	Iron (ppm)	74	50	15	2	3.4	<.5^
	Sodium (ppm)	51	110	100	90	85	120^
	Chloride (ppm)	-	-	-	-	1.1	85
	Sulfate (ppm)	-	-	-	-	11	<5
	GROUND-WATER CONTAMINATION PARAMETERS						
	pH	6.00	6.22	6.23	6.32	6.28	-
	Conductivity (umhos/cm)	1910	3060	3430	3290	3010	-
	TOC (ppm)	-	-	-	-	-	2.9
	TOX (ppb)	-	-	-	-	-	2
	Summed VOC'S (ppb)	ND	ND	ND	ND	ND	(LT) 5
	MISC. PARAMETERS						
	TSS (ppm)	-	-	-	-	-	6
	Calcium (ppm)	230	390	400	460	460	830^
	Uranium (ppm)	-	-	-	-	-	<.001

CHEMICAL ANALYSES OF GROUND WATER FROM
PHASE IV MONITOR WELLS IN THE S-3 POND AREA

QUARTER SAMPLED: OCT. '85
LABORATORY: K-25

TYPE ANALYSIS FOR METALS: UNFILTERED ICP

WELL NUMBER	PARAMETER	SAMPLE #1	SAMPLE #2	SAMPLE #3
GW-123	EPA INTERIM PRIMARY DRINKING WATER STANDARD			
	Arsenic (ppm)	-	-	-
	Barium (ppm)	0.10	0.017	0.014
	Cadmium (ppm)	<0.030	<0.030	<0.030
	Chromium (ppm)	0.23	0.23	0.19
	Lead (ppm)	<0.50	<0.50	<0.50
	Mercury (ppm)	-	-	-
	Selenium (ppm)	-	-	-
	Silver (ppm)	<0.060	<0.060	<0.060
	Nitrate/Nitrite as N (ppm)	-	-	(N)113
	Fluoride (ppm)	-	-	4.5
	Gross Alpha (pCi/l)	-	-	-
	Gross Beta (pCi/l)	-	-	-
	GROUND-WATER QUALITY PARAMETERS			
	Manganese (ppm)	4.1	0.39	0.42
	Iron (ppm)	240	28	30
	Sodium (ppm)	740	780	870
	Chloride (ppm)	-	-	770
	Sulfate (ppm)	-	-	91
	GROUND-WATER CONTAMINATION PARAMETERS			
	pH	11.43	11.12	10.3
	Conductivity (umhos/cm)	5740	4490	6080
	TOC (ppm)	-	-	-
	TOX (ppb)	-	-	-
	Summed VOC'S (ppb)	14	6	8
	MISC. PARAMETERS			
	TSS (ppm)	-	-	-
	Calcium (ppm)	37	2.5	2.5
	Uranium (ppm)	-	-	-

CHEMICAL ANALYSIS OF GROUND WATER FROM
PHASE IV MONITOR WELLS IN THE S-3 POND AREA

QUARTER SAMPLED LABORATORY		OCT. '85 K-25					SEPT. '86 WESTON
TYPE ANALYSIS FOR METALS		UNFILTERED ICP					FILTERED AAS
WELL NUMBER	PARAMETER	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4	SAMPLE #5	
GW-124	EPA INTERIM PRIMARY DRINKING WATER STANDARD						
	Arsenic (ppm)	-	-	-	-	-	<.01
	Barium (ppm)	0.38	1.2	1.2	1.0	0.99	2.7
	Cadmium (ppm)	<0.030	<0.030	<0.030	<0.030	<0.030	<.0025
	Chromium (ppm)	0.20	0.24	0.25	0.25	0.19	<.01
	Lead (ppm)	<0.50	<0.50	<0.50	<0.50	<0.50	<.005
	Mercury (ppm)	-	-	-	-	-	<.0002
	Selenium (ppm)	-	-	-	-	-	<.01
	Silver (ppm)	<0.060	<0.060	<0.060	<0.060	<0.060	<.01
	Nitrate/Nitrite (ppm)	-	-	-	-	1700	300
	Fluoride (ppm)	-	-	-	-	1.6	-
	Gross Alpha (pCi/l)	-	-	-	-	-	8
	Gross Beta (pCi/l)	-	-	-	-	-	490
	GROUND-WATER QUALITY PARAMETERS						
	Manganese (ppm)	1.6	3.3	3.4	2.3	2.0	.06^
	Iron (ppm)	32	19	23	4.6	2.6	<.5^
	Sodium (ppm)	110	110	110	100	94	80^
	Chloride (ppm)	-	-	-	-	200	130
	Sulfate (ppm)	-	-	-	-	160	9
	GROUND-WATER CONTAMINATION PARAMETERS						
	pH	6.07	5.97	5.91	6.07	6.9	-
	Conductivity (umhos/cm)	2350	3630	3800	3550	3490	-
	TOC (ppm)	-	-	-	-	-	2.8
	TOX (ppb)	-	-	-	-	-	40
	Summed VOC'S (ppb)	33	21	17	19	19	51
	MISC. PARAMETERS						
	TSS (ppm)	-	-	-	-	-	4
	Calcium (ppm)	250	500	610	560	540	610^
	Uranium (ppm)	-	-	-	-	-	0.007

CHEMICAL ANALYSIS OF ʼUND WATER FROM
PHASE IV MONITOR WELL .N THE S-3 POND AREA

QUARTER SAMPLED — OCT. '85
LABORATORY — K-25

TYPE ANALYSIS FOR METALS — UNFILTERED ICP

WELL NUMBER	PARAMETER	SAMPLE #1	SAMPLE #2	SAMPLE #3
GW-125	EPA INTERIM PRIMARY DRINKING WATER STANDARD			
	Arsenic (ppm)	-	-	-
	Barium (ppm)	0.35	0.080	0.14
	Cadmium (ppm)	<0.030	<0.030	<0.030
	Chromium (ppm)	0.22	0.20	0.24
	Lead (ppm)	<0.50	<0.50	<0.50
	Mercury (ppm)	-	-	-
	Selenium (ppm)	-	-	-
	Silver (ppm)	<0.060	<0.060	<0.060
	Nitrate/Nitrite as N (ppm)	-	-	(N)080
	Fluoride (ppm)	-	-	1.7
	Gross Alpha (pCi/l)	-	-	-
	Gross Beta (pCi/l)	-	-	-
	GROUND-WATER QUALITY PARAMETERS			
	Manganese (ppm)	0.044	0.07	0.14
	Iron (ppm)	3.8	7.5	15
	Sodium (ppm)	410	650	640
	Chloride (ppm)	-	-	844
	Sulfate (ppm)	-	-	101
	GROUND-WATER CONTAMINATION PARAMETERS			
	pH	11.25	9.48	11.02
	Conductivity (umhos/cm)	5180	3360	4960
	TOC (ppm)	-	-	-
	TOX (ppb)	-	-	-
	Summed VOC'S (ppb)	29	7	12
	MISC. PARAMETERS			
	TSS (ppm)	-	-	-
	Calcium (ppm)	380	34	210
	Uranium (ppm)	-	-	-

APPENDIX B.2

OIL LANDFARM WELLS

GW-120

GW-225

GW-226

GW-227

GW-228

GW-229

CHEMICAL ANALYSIS OF G. ND WATER FROM
PHASE IV MONITOR WELLS IN THE OIL LANDFARM

QUARTER SAMPLED LABORATORY		OCT. '85 K-25				JAN. '86 WESTON	MAY '86 WESTON	SEPT. '86 WESTON
TYPE ANALYSIS FOR METALS		UNFILTERED ICP				FILTERED AAS	FILTERED AAS	FILTERED AAS
WELL NUMBER	PARAMETER	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4			
GW-120	EPA INTERIM PRIMARY DRINKING WATER STANDARD							
	Arsenic (ppm)	-	-	-	-	<.01	<0.005	<.01
	Barium (ppm)	0.034	0.055	0.10	0.14	<0.5^	0.17	0.26
	Cadmium (ppm)	<0.030	<0.030	<0.030	<0.030	<0.5^	<0.0025	<0.0025
	Chromium (ppm)	0.20	0.20	0.20	0.22	<0.5^	<0.010	<0.010
	Lead (ppm)	<0.50	<0.50	<0.50	<0.50	<0.005	<0.005	<0.005
	Mercury (ppm)	-	-	-	-	-	<0.0005	<.0002
	Selenium (ppm)	-	-	-	-	<0.005	<0.005	<0.010
	Silver (ppm)	<0.060	<0.060	<0.060	<0.060	<0.5^	<0.010	<0.010
	Nitrate/Nitrite as N (ppm)	-	-	-	(N) 4.7	0.8	0.060	(N)(T) <1
	Fluoride (ppm)	-	-	-	0.24	-	-	-
	Gross Alpha (pCi/l)	-	-	-	-	<1	<5	<5
	Gross Beta (pCi/l)	-	-	-	-	4	<5	<3
	GROUND-WATER QUALITY PARAMETERS							
	Manganese (ppm)	0.067	0.042	<0.010	0.022	<0.5^	<0.5^	<0.5^
	Iron (ppm)	7.5	2.2	0.89	2.5	<0.5^	<0.5^	<0.5^
	Sodium (ppm)	72	82	85	84	76^	70^	91^
	Chloride (ppm)	-	-	-	2	6.9	3.6	5.4
	Sulfate (ppm)	-	-	-	9.5	<5	5.4	6.7
	GROUND-WATER CONTAMINATION PARAMETERS							
	pH	9.74	9.07	8.63	8.39	8.5	-	-
	Conductivity (umhos/cm)	380	430	400	390	280	-	-
	TOC (ppm)	-	-	-	-	<0.5	0.70	0.65
	TOX (ppb)	-	-	-	-	-	1.0	2
	Summed VOC'S (ppb)	ND	ND	ND	ND	(LT) 5	(LT) 5	-
	MISC. PARAMETERS							
	TSS (ppm)	-	-	-	-	2	<1 0	-
	Calcium (ppm)	6.1	4.1	6.1	7.4	6.9^	6.4^	6.1^
	Uranium (ppm)	-	-	-	-	<0.001	<.001	<.001

CHEMICAL ANALYSIS OF GROUND WATER FROM
PHASE IV MONITOR WELLS IN THE OIL LANDFARM AREA

QUARTER SAMPLED LABORATORY		JAN. '86 K-25	JAN. '86 WESTON	MAY '86 WESTON	MAY '86 K-25	SEPT. '86 WESTON	SEPT. '86 K-25
TYPE ANALYSIS FOR METALS		FILTERED AAS	FILTERED AAS	FILTERED AAS	FILTERED AAS	FILTERED AAS	FILTERED AAS
WELL NUMBER	PARAMETER						
GW-225	EPA INTERIM PRIMARY DRINKING WATER STANDARDS						
	Arsenic (ppm)	<0.005	<0.01	<0.010	<.005	<.01	<.005
	Barium (ppm)	0.14*	<0.5*	0.21	.15*	0.14	.13*
	Cadmium (ppm)	<0.003*	<0.5*	<0.0025	<.003*	<.0025	<.003*
	Chromium (ppm)	<0.01*	<0.5*	<0.010	<.01*	<.01	<.01*
	Lead (ppm)	0.006	0.012	<0.005	<.004	<0.005	0.008
	Mercury (ppm)	<0.0002	-	<0.0005	<0.0002	<0.0002	<0.0002
	Selenium (ppm)	<0.005	<0.005	<0.005	<0.005	<.01	<0.005
	Silver (ppm)	<0.006*	0.67*	<0.010	<.006*	<.01	<.006*
	Nitrate/Nitrite as N (ppm)	(N)48.1	47	39	(N)65.3	42	(N)71.8
	Fluoride (ppm)	-	-	-	-	-	-
	Gross Alpha (pCi/l)	3	<2	5+/-3	2.6	<5	4
	Gross Beta (pCi/l)	10	13	6+/-5	10.3	6	11
	GROUND-WATER QUALITY PARAMETERS						
	Manganese (ppm)	0.0049*	<0.5*	<0.5*	.0077*	<0.5*	.0088*
	Iron (ppm)	.045*	<0.5*	<0.5*	<.004*	<0.5*	.1*
	Sodium (ppm)	11*	9*	7.7*	11*	11*	9.5*
	Chloride (ppm)	9.1	9.9	11	8.5	14	9.6
	Sulfate (ppm)	34	32	32	34	17	30
	GROUND-WATER CONTAMINATION PARAMETERS						
	pH	7.41	7.4	-	-	-	-
	Conductivity (umhos/cm)	728	650	-	-	-	-
	TOC (ppm)	63	<0.5	<0.5	58	1.5	53
	TOX (ppb)	154	-	70	55	200	359
	Summed VOC'S (ppb)	521	380	866	529	625	369
	MISC. PARAMETERS						
	TSS (ppm)	3	6	1	6	1	2
	Calcium (ppm)	100*	110*	100*	120*	130*	110*
	Uranium (ppm)	0.003	<0.001	<0.001	0.002	0.002	0.002

CHEMICAL ANALYSIS OF GROUND WATER FROM PHASE IV MONITOR WELLS IN THE OIL LANDFARM AREA

QUARTER SAMPLED LABORATORY		JAN. '86 K-25	JAN. '86 WESTON	MAY '86 WESTON	MAY '86 K-25	SEPT. '86 WESTON	SEPT. '86 K-25
TYPE ANALYSIS FOR METALS		FILTERED AAS	FILTERED AAS	FILTERED AAS	FILTERED AAS	FILTERED AAS	FILTERED AAS
WELL NUMBER	PARAMETER						
GW-226	EPA INTERIM PRIMARY DRINKING WATER STANDARDS						
	Arsenic (ppm)	<0.005	<0.01	<0.010	<0.005	<.01	<0.005
	Barium (ppm)	0.16^	<0.5^	0.39	.18^	0.19	.14^
	Cadmium (ppm)	<0.003^	<0.5^	<0.0025	<0.003^	<0.0025	<0.003^
	Chromium (ppm)	<0.01^	<0.5^	<0.010	<0.01^	<0.010	<0.01^
	Lead (ppm)	0.027	<0.005	<0.005	<.004	<.005	0.006
	Mercury (ppm)	<0.0002	-	<0.0005	<0.0002	<0.0002	<0.0002
	Selenium (ppm)	<0.005	<0.005	<0.005	<.005	<0.010	<.005
	Silver (ppm)	<0.006^	<0.5^	<0.010	<0.006^	<0.010	<0.006^
	Nitrate/Nitrite as N (ppm)	(N) 14.22	12	0.72	(N) 9.64	4	(N) 11.3
	Fluoride (ppm)	-	-	-	-	-	-
	Gross Alpha (pCi/l)	56	11	<7	3.2	7	<2
	Gross Beta (pCi/l)	50	31	9+/-3	6.6	9	6
	GROUND-WATER QUALITY PARAMETERS						
	Manganese (ppm)	1.7^	1.4^	1.8^	2.5^	1.2^	1.7^
	Iron (ppm)	<.004^	<0.5^	.87^	.85^	<0.5^	.57^
	Sodium (ppm)	9.9^	8.9^	6.4^	9.1^	8.9^	7.9^
	Chloride (ppm)	25.7	21	22	19.5	22	20.8
	Sulfate (ppm)	27	27	26	27	15	25
	GROUND-WATER CONTAMINATION PARAMETERS						
	pH	6.98	6.8	-	-	-	-
	Conductivity (umhos/cm)	806	800	-	-	-	-
	TOC (ppm)	94	1.6	1.5	156	1.5	142
	TOX (ppb)	23	-	BROKEN	93	100	110
	Summed VOC'S (ppb)	160	140	133	119	134	72
	MISC. PARAMETERS						
	TSS (ppm)	754	780	10	15	190	318
	Calcium (ppm)	150^	160^	180^	160^	150^	140^
	Uranium (ppm)	0.007	<0.001	<0.001	0.004	0.005	0.006

CHEMICAL ANALYSIS OF GROUND WATER FROM
PHASE IV MONITOR WELLS IN THE OIL LANDFARM AREA

		JAN. '86	JAN. '86	MAY '86	MAY '86	SEPT. '86	SEPT. '86
QUARTER SAMPLED LABORATORY		K-25	WESTON	WESTON	K-25	WESTON	K-25
TYPE ANALYSIS FOR METALS		FILTERED AAS	FILTERED AAS	FILTERED AAS	FILTERED AAS	FILTERED AAS	FILTERED AAS
WELL NUMBER	PARAMETER						
GW-227	EPA INTERIM PRIMARY DRINKING WATER STANDARDS						
	Arsenic (ppm)	<0.005	<0.01	<0.010	<0.005	<0.01	<0.005
	Barium (ppm)	0.17^	<0.5^	0.075	.12^	0.33	.2^
	Cadmium (ppm)	<0.003^	<0.5^	<0.0025	<0.003^	<0.0025	<0.003^
	Chromium (ppm)	<0.01^	<0.5^	<0.010	<0.01^	<0.010	<0.01^
	Lead (ppm)	<0.004	<0.005	<0.005	<0.004	<0.005	<0.004
	Mercury (ppm)	<0.0002	-	<0.0005	<0.0002	<0.0002	<0.0002
	Selenium (ppm)	<0.005	<0.005	<0.005	<0.005	<0.010	<0.005
	Silver (ppm)	<0.006^	<0.5^	<0.010	<0.006^	<0.010	<0.006^
	Nitrate/Nitrite as N (ppm)	(N)66.5	60	23	(N)48.3	34	(N)67.3
	Fluoride (ppm)	-	-	-	-	-	-
	Gross Alpha (pCi/l)	132	56	43+/-13	47.2	24	53
	Gross Beta (pCi/l)	176	160	94+/-6	105	110	116
	GROUND-WATER QUALITY PARAMETERS						
	Manganese (ppm)	.15^	<0.5^	<0.5^	.11^	<0.5^	.31^
	Iron (ppm)	.72^	.68^	<0.5^	<.004^	<0.5^	0.014
	Sodium (ppm)	16^	20^	11^	14^	19^	20^
	Chloride (ppm)	35	44	26	27.5	60	37
	Sulfate (ppm)	46	46	37	39	30	53
	GROUND-WATER CONTAMINATION PARAMETERS						
	pH	7.03	6.8	-	-	-	-
	Conductivity (umhos/cm)	955	710	-	-	-	-
	TOC (ppm)	96	1.1	1.1	61	1.2	94
	TOX (ppb)	19	-	320	205	31	72
	Summed VOC'S (ppb)	30	51	52	39	63	18
	MISC. PARAMETERS						
	TSS (ppm)	10	10	3	9	<1	<1
	Calcium (ppm)	160^	180^	150^	140^	180^	190^
	Uranium (ppm)	0.163	0.001	0.001	0.068	0.11	0.109

CHEMICAL ANALYSIS OF GROUND WATER FROM
PHASE IV MONITOR WELLS IN THE OIL LANDFARM AREA

QUARTER SAMPLED LABORATORY		JAN. '86 K-25	JAN. '86 WESTON	MAY '86 WESTON	MAY '86 K-25	SEPT. '86 WESTON	SEPT. '86 K-25
TYPE ANALYSIS FOR METALS		FILTERED AAS	FILTERED AAS	FILTERED AAS	FILTERED AAS	FILTERED AAS	FILTERED AAS
WELL NUMBER	PARAMETER						
GW-228	EPA INTERIM PRIMARY DRINKING WATER STANDARDS						
	Arsenic (ppm)	<0.005	<0.01	<0.010	<0.005	<0.01	<0.005
	Barium (ppm)	0.054^	<0.5^	0.098	.078^	0.18	.097^
	Cadmium (ppm)	<0.003^	<0.5^	<0.0025	<0.003^	<0.0025	<0.003^
	Chromium (ppm)	<0.01^	<0.5^	0.029	.011^	<0.01	<.01^
	Lead (ppm)	<0.004	<0.005	<0.005	<0.004	<0.005	0.004
	Mercury (ppm)	<0.0002	-	<0.0005	<0.0002	<0.0002	<0.0002
	Selenium (ppm)	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005
	Silver (ppm)	<0.006^	<0.5^	<0.010	<0.006^	<0.01	<0.006^
	Nitrate/Nitrite as N (ppm)	(N) 19.2	20	18	(N) 24.4	10	(N) 15.4
	Fluoride (ppm)	-	-	-	-	-	-
	Gross Alpha (pCi/l)	17	<4	<5	4.4	<5	<2
	Gross Beta (pCi/l)	85	92	19+/-3	19.3	13	10
	GROUND-WATER QUALITY PARAMETERS						
	Manganese	.0039^	<0.5^	<0.5^	.0089^	<0.5^	.069^
	Iron (ppm)	.016^	1.1^	<0.5^	.02^	<0.5^	.095^
	Sodium (ppm)	15^	19^	8.7	12^	12^	12^
	Chloride (ppm)	17	25	21	18.9	47	18
	Sulfate (ppm)	69	65	50	49	34	53
	GROUND-WATER CONTAMINATION PARAMETERS						
	pH	8.47	9.3	-	-	-	-
	Conductivity (umhos/cm)	514	355	-	-	-	-
	TOC (ppm)	23	4.2	1.3	51	2.7	76
	TOX (ppb)	0.203	-	1100	170	90	104
	Summed VOC'S (ppb)	208	247	121	87	145	62
	MISC. PARAMETERS						
	TSS (ppm)	36	57	68	51	210	24
	Calcium (ppm)	28^	29^	54^	51^	93^	95^
	Uranium (ppm)	0.002	<0.001	<0.001	0.003	0.003	0.003

CHEMICAL ANALYSIS OF GROUND WATER FROM
PHASE IV MONITOR WELLS IN THE OIL LANDFARM AREA

QUARTER SAMPLED / LABORATORY		JAN. '86 K-25	JAN. '86 WESTON	MAY '86 WESTON	MAY '86 K-25	SEPT. '86 WESTON	SEPT. '86 K-25
TYPE ANALYSIS FOR METALS		FILTERED AAS	FILTERED AAS	FILTERED AAS	FILTERED AAS	FILTERED AAS	FILTERED AAS
WELL NUMBER	PARAMETER						
GW-229	EPA INTERIM PRIMARY DRINKING WATER STANDARDS						
	Arsenic (ppm)	0.007	<0.01	<0.010	<.005	<0.01	<.005
	Barium (ppm)	1.1^	1.3^	0.81	.62^	0.73	.44^
	Cadmium (ppm)	<0.003^	<0.5^	<0.0025	<0.003^	<0.0025	<.003^
	Chromium (ppm)	<0.01^	<0.5^	<0.010	<.01^	<0.01	<.01^
	Lead (ppm)	0.009	<0.005	<0.005	<.004	<0.005	<.004
	Mercury (ppm)	<0.0002	-	<0.0005	<0.0002	<0.0002	<0.0002
	Selenium (ppm)	<0.005	<0.005	<0.005	0.002	<0.01	<0.005
	Silver (ppm)	<0.006^	<0.5^	<0.010	<0.006^	<0.01	<0.006^
	Nitrate/Nitrite as N (ppm)	(N)0.38	<0.05	0.11	(N)<.11	<.05	(N)<.11
	Fluoride (ppm)	-	-	-	-	-	-
	Gross Alpha (pCi/l)	34	<6	<13	5.3	6	9
	Gross Beta (pCi/l)	19	23	29+/-9	13.1	8	8
	GROUND-WATER QUALITY PARAMETERS						
	Manganese (ppm)	6.4^	4.6^	5^	5.9^	3.9^	4.5^
	Iron (ppm)	19^	20^	1.1^	13^	11^	6.5^
	Sodium (ppm)	77^	79^	36^	47^	37^	27^
	Chloride (ppm)	158	200	120.0	212	17	86
	Sulfate (ppm)	17	11	18.0	16	11	22
	GROUND-WATER CONTAMINATION PARAMETERS						
	pH	7.56	6.5	-	-	-	-
	Conductivity (umhos/cm)	1048	1130	-	-	-	-
	TOC (ppm)	159	19	6	205	7.7	170
	TOX (ppb)	0.148	-	30	343	60	94
	Summed VOC'S (ppb)	28	(LT) 35	58	37	65	78
	MISC. PARAMETERS						
	TSS (ppm)	150	50	58	51	78	69
	Calcium (ppm)	180^	210^	200^	180^	160^	150^
	Uranium (ppm)	0.016	<0.001	<0.001	0.013	0.021	0.019

APPENDIX B.3

BURIAL GROUNDS WELLS

GW-116

GW-117

GW-118

GW-119

GW-126

CHEMICAL ANALYSIS OF GROUND WATER FROM
PHASE IV MONITOR WELLS IN THE BURIAL GROUNDS

QUARTER SAMPLED			SEPT. '85		JAN. '86	MAY '86	AUG. '86
LABORATORY			K-25		WESTON	WESTON	WESTON
TYPE ANALYSIS FOR METALS			UNFILTERED ICP		FILTERED AAS	FILTERED AAS	FILTERED AAS
WELL NUMBER	PARAMETER	SAMPLE #1	SAMPLE #2	SAMPLE #3			
GW-116	EPA INTERIM PRIMARY DRINKING-WATER STANDARDS						
	Arsenic (ppm)	-	-	-	<0.010	<0.010	<0.010
	Barium (ppm)	<0.010	0.014	0.017	<0.5^	0.047	0.030
	Cadmium (ppm)	<0.030	<0.030	<0.030	<0.5^	<0.0025	<0.0025
	Chromium (ppm)	0.19	0.23	0.19	<0.5^	<0.010	<0.010
	Lead (ppm)	<0.50	<0.50	-	<0.005	<0.005	<0.005
	Mercury (ppm)	-	-	-	-	<0.0005	<.0002
	Selenium (ppm)	-	-	-	<0.005	<0.005	<0.010
	Silver (ppm)	<0.060	<0.060	<0.060	<0.5^	<0.010	<0.010
	Nitrate/Nitrite as N (ppm)	-	-	(N)3.2	0.06	(N)(T)<1.0	<.05
	Fluoride (ppm)	-	-	1.6	-	-	-
	Gross Alpha (pCi/l)	-	-	-	<2	<5	10
	Gross Beta (pCi/l)	-	-	-	<3	<5	4
	GROUND-WATER QUALITY PARAMETERS						
	Manganese (ppm)	0.045	0.041	0.032	<0.5^	<0.5^	<0.5^
	Iron (ppm)	3.9	4.7	2.9	<0.5^	<0.5^	<0.5^
	Sodium (ppm)	150	160	160	23^	210^	50^
	Chloride (ppm)	-	-	2.9	<5	3.5	<2.5
	Sulfate (ppm)	-	-	37	20	23	8
	GROUND-WATER CONTAMINATION PARAMETERS						
	pH	9.37	9.35	9.28	9.40	-	-
	Conductivity (umhos/cm)	690	700	670	450.00	-	-
	TOC (ppm)	-	-	-	<0.5	<0.5	<0.5
	TOX (ppb)	-	-	-	-	1.0	<1
	Summed VOC'S (ppb)	ND	ND	ND	(LT) 10	-	(LT) 5
	MISC. PARAMETERS						
	TSS (ppm)	-	-	-	1.00	-	4
	Calcium (ppm)	2.0	2.2	1.5	0.96^	1^	.7^
	Uranium (ppm)	-	-	-	<0.001	<0.001	<0.001

CHEMICAL ANALYSIS OF GROUND WATER FROM
PHASE IV MONITOR WELLS IN THE BURIAL GROUNDS

QUARTER SAMPLED: OCT. '85
LABORATORY: K-25

TYPE ANALYSIS FOR METALS: UNFILTERED ICP

WELL NUMBER	PARAMETER	SAMPLE #1	SAMPLE #2	SAMPLE #3
GW-117	**EPA INTERIM PRIMARY DRINKING-WATER STANDARDS**			
	Arsenic (ppm)	-	-	-
	Barium (ppm)	0.024	0.027	0.019
	Cadmium (ppm)	<0.030	<0.030	<0.030
	Chromium (ppm)	0.17	0.16	0.17
	Lead (ppm)	<0.50	<0.50	<0.50
	Mercury (ppm)	-	-	-
	Selenium (ppm)	-	-	-
	Silver (ppm)	<0.060	<0.060	<0.060
	Nitrate/Nitrite as N (ppm)	-	-	(N)<1
	Fluoride (ppm)	-	-	3.4
	Gross Alpha (pCi/l)	-	-	-
	Gross Beta (pCi/l)	-	-	-
	GROUND-WATER QUALITY PARAMETERS			
	Manganese (ppm)	0.14	0.15	0.13
	Iron (ppm)	16	16	16
	Sodium (ppm)	770	840	820
	Chloride (ppm)	-	-	570
	Sulfate (ppm)	-	-	27
	GROUND-WATER CONTAMINATION PARAMETERS			
	pH	11.58	11.44	11.59
	Conductivity (umhos/cm)	6490	5540	6530
	TOC (ppm)	-	-	-
	TOX (ppb)	-	-	-
	Summed VOC'S (ppb)	7584	7077	8176
	MISC. PARAMETERS			
	TSS (ppm)	-	-	-
	Calcium (ppm)	5.0	4.2	3.7
	Uranium (ppm)	-	-	-

CHEMICAL ANALYSIS OF GROUND WATER FROM
PHASE IV MONITOR WELLS IN THE BURIAL GROUNDS

QUARTER SAMPLED: OCT. '85
LABORATORY: K-25

TYPE ANALYSIS FOR METALS: UNFILTERED ICP

WELL NUMBER: GW-118

PARAMETER	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4
EPA INTERIM PRIMARY DRINKING-WATER STANDARDS				
Arsenic (ppm)	-	-	-	-
Barium (ppm)	0.051	0.26	0.037	0.025
Cadmium (ppm)	<0.030	<0.030	<0.030	<0.030
Chromium (ppm)	0.26	0.21	0.23	0.26
Lead (ppm)	<0.50	<0.50	<0.50	<0.50
Mercury (ppm)	-	-	-	-
Selenium (ppm)	-	-	-	-
Silver (ppm)	<0.060	<0.060	<0.060	<0.060
Nitrate/Nitrite as N (ppm)	-	-	-	(N)<10
Fluoride (ppm)	-	-	-	-
Gross Alpha (pCi/l)	-	-	-	-
Gross Beta (pCi/l)	-	-	-	-
GROUND-WATER QUALITY PARAMETERS				
Manganese (ppm)	0.5	0.18	0.22	0.25
Iron (ppm)	61	20	23	22
Sodium (ppm)	950	1900	1800	1700
Chloride (ppm)	-	-	-	2060
Sulfate (ppm)	-	-	-	22
GROUND-WATER CONTAMINATION PARAMETERS				
pH	11.84	9.59	10.46	11.29
Conductivity (umhos/cm)	10080	8210	8250	8750
TOC (ppm)	-	-	-	-
TOX (ppb)	-	-	-	-
Summed VOC'S (ppb)	16	ND	6	11
MISC. PARAMETERS				
TSS (ppm)	-	-	-	-
Calcium (ppm)	70	13	13	8.1
Uranium (ppm)	-	-	-	-

CHEMICAL ANALYSIS OF GROUND WATER FROM
PHASE IV MONITOR WELLS IN THE BURIAL GROUNDS

QUARTER SAMPLED: OCT. '85
LABORATORY: K-25

TYPE ANALYSIS FOR METALS: UNFILTERED ICP

WELL NUMBER	PARAMETER	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4
GW-119	EPA INTERIM PRIMARY DRINKING-WATER STANDARDS				
	Arsenic (ppm)	-	-	-	-
	Barium (ppm)	<0.010	0.029	0.018	0.016
	Cadmium (ppm)	<0.030	<0.030	<0.030	<0.030
	Chromium (ppm)	0.20	0.21	0.22	0.23
	Lead (ppm)	<0.50	<0.50	<0.50	<0.50
	Mercury (ppm)	-	-	-	-
	Selenium (ppm)	-	-	-	-
	Silver (ppm)	<0.060	<0.060	<0.060	<0.060
	Nitrate/Nitrite as N (ppm)	-	-	-	(N)<10
	Fluoride (ppm)	-	-	-	3.3
	Gross Alpha (pCi/l)	-	-	-	-
	Gross Beta (pCi/l)	-	-	-	-
	GROUND-WATER QUALITY PARAMETERS				
	Manganese (ppm)	0.035	0.087	0.085	0.083
	Iron (ppm)	3.7	9.6	9.7	9.4
	Sodium (ppm)	940	1100	1000	1000
	Chloride (ppm)	-	-	-	740
	Sulfate (ppm)	-	-	-	33
	GROUND-WATER CONTAMINATION PARAMETERS				
	pH	11.58	10.26	11.09	11.39
	Conductivity (umhos/cm)	7310	5340	5990	6660
	TOC (ppm)	-	-	-	-
	TOX (ppb)	-	-	-	-
	Summed VOC'S (ppb)	ND	ND	ND	ND
	MISC. PARAMETERS				
	TSS (ppm)	-	-	-	-
	Calcium (ppm)	3.5	4.6	4.4	3.0
	Uranium (ppm)	-	-	-	-

CHEMICAL ANALYSIS OF GROUND WATER FROM
PHASE IV MONITOR WELLS IN THE BURIAL GROUNDS

QUARTER SAMPLED LABORATORY		SEPT. '85 K-25			JAN. '86 WESTON	MAY '86 WESTON	AUG. '86 WESTON
TYPE ANALYSIS FOR METALS		UNFILTERED ICP			FILTERED AAS	FILTERED AAS	FILTERED AAS
WELL NUMBER	PARAMETER	SAMPLE #1	SAMPLE #2	SAMPLE #3			
GW-126	EPA INTERIM PRIMARY DRINKING-WATER STANDARDS						
	Arsenic (ppm)	-	-	-	<0.010	<0.010	<0.010
	Barium (ppm)	0.020	0.044	0.030	<0.5^	0.087	0.043
	Cadmium (ppm)	<0.030	<0.030	<0.030	<0.5^	<0.0025	<0.0025
	Chromium (ppm)	0.19	0.18	0.25	<0.5^	<0.010	<0.010
	Lead (ppm)	<0.50	<0.50	<0.50	<0.005	<0.005	<0.005
	Mercury (ppm)	-	-	-	-	<0.0005	<.0002
	Selenium (ppm)	-	-	-	<0.005	<0.005	<0.010
	Silver (ppm)	<0.060	<0.060	<0.060	<0.5^	<0.010	<0.010
	Nitrate/Nitrite as N (ppm)	-	-	(N)<1	<0.05	(N)(T) <1	<.05
	Fluoride (ppm)	-	-	1	-	-	-
	Gross Alpha (pCi/1)	-	-	-	<2	<5	6
	Gross Beta (pCi/1)	-	-	-	<4	9+/-4	4
	GROUND-WATER QUALITY PARAMETERS						
	Manganese (ppm)	0.072	0.11	0.068	<0.5^	<0.5^	<0.5^
	Iron (ppm)	6.3	7	3.5	<0.5^	<0.5^	<0.5^
	Sodium (ppm)	150	150	140	150^	160^	200^
	Chloride (ppm)	-	-	9.9	14.0	13.0	15.0
	Sulfate (ppm)	-	-	25	33.0	28	16
	GROUND-WATER CONTAMINATION PARAMETERS						
	pH	9.21	9.24	9.23	8.90	-	-
	Conductivity (umhos/cm)	610	630	620	550.00	-	-
	TOC (ppm)	-	-	-	<0.5	<0.5	1.2
	TOX (ppb)	-	-	-	-	<1.0	9
	Summed VOC'S (ppb)	ND	ND	11	(LT)5	-	(LT) 5
	MISC. PARAMETERS						
	TSS (ppm)	-	-	-	15.0	-	16
	Calcium (ppm)	3.1	2.4	2.3	2.2^	1.6^	1^
	Uranium (ppm)	-	-	-	<0.001	<.001	<.001

APPENDIX C

GROUND-WATER QUALITY STANDARDS

GROUND-WATER QUALITY STANDARDS

PARAMETER	MAXIMUM LEVEL mg/L
SELECTED EPA INTERIM PRIMARY DRINKING-WATER STANDARDS	
Arsenic	0.05
Barium	1.00
Cadmium	0.01
Chromium	0.05
Lead	0.05
Mercury	0.002
Selenium	0.01
Silver	0.05
Nitrate as N	10.00
Fluoride	1.4-2.4
Gross Alpha (pCi/l)	15.00
Gross Beta (millirem/yr)	4.00
SECONDARY DRINKING-WATER STANDARDS	
GROUND-WATER QUALITY PARAMETERS	
Manganese	0.05
Iron	0.30
Chloride	250.00
Sulfate	250.00
Sodium (total)	9.6*
GROUND-WATER CONTAMINATION PARAMETERS	
pH	6.5-8.5
Conductivity (umhos/cm)	297*
TOC	1.5*
TOX (ppb)	4.0*

* Average values from background wells GW-115 (S-3 Ponds), GW-84 (Oil Landfarm), and GW-40 (Burial Grounds)

APPENDIX D

PRIORITY POLLUTANT VOLATILE ORGANICS

PRIORITY POLLUTANT VOLATILE ORGANICS

1,1,1-TRICHLOROETHANE
1,1,2,2-TETRACHLOROETHANE
1,1,2-TRICHLOROETHANE
1,1-DICHLOROETHANE
1,1-DICHLOROETHENE
1,2-DICHLOROETHANE
1,2-DICHLOROPROPANE
2-CHLOROETHYLVINYL ETHER
ACROLEIN
ACRYLONITRILE
BENZENE
BROMODICHLOROMETHANE
BROMOFORM
BROMOMETHANE
CARBON TETRACHLORIDE
CHLOROBENZENE
CHLORODIBROMOMETHANE
CHLOROETHANE
CHLOROFORM
CHLOROMETHANE
CIS-1,3-DICHLOROPROPENE
DICHLORODIFLOUROMETHANE
ETHYLBENZENE
FLOUROTRICHLOROMETHANE
METHYLENE CHLORIDE
TETRACHLOROETHENE
TOLUENE
TRANS-1,2-DICHLOROETHENE
TRANS-1,3-DICHLOROPROPENE
TRICHLOROETHENE
VINYL CHLORIDE

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Distribution:

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